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NATIONAL TRANSPORTATION SAFETY BOARD

Washington, D.C.

Operations/Human Performance Group Chairmen
US Airways A320 Training Manual 7-27.1.5
Control Laws

(3 Pages)

Attachment 20

to Operations / Human Performance Group Factual Report

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US AIRWAYS A320 TM 7-27.1.5
CONTROL LAWS

Full Ground Spoiler Extension. The spoilers extend automatically at touchdown of both main gear or in case of a rejected takeoff (speed above 72 knots) when:

— both thrust levers are at idle (if the ground spoilers are ARMED) or

— reverse thrust is selected on at least one engine with the other thrust lever at idle (if the ground spoilers are not ARMED)

Rudder. One rudder surface controls yaw. In flight, with the autopilot engaged, automatic rudder trim is accomplished through inputs from the FACs and FMGCs.

The rudder is electrically controlled by trim motors, or mechanically controlled by the rudder pedals. It is hydraulically actuated by either system. Rudder deflection is limited according to airspeed. If both FACs fail, maximum rudder deflection can be obtained when the slats are extended.

Manual rudder trim is accomplished using the electric RUD TRIM switch. A button located on the rudder trim panel is provided to reset rudder trim to 0. The RUD TRIM switch and RESET button are deactivated with the autopilot engaged.

7-27.1.4 Flaps and Slats. There are two flap (double-slotted in the case of the A321) and five slat surfaces on each wing. These surfaces are electrically controlled and hydraulically actuated. Signals from the FLAPS lever position are transmitted to two Slat Flap Control Computers (SFCCs).

The slats are powered by both the green and blue hydraulic systems. The flaps are powered by both the green and yellow hydraulic systems. If one hydraulic system fails, the associated surfaces extend and retract at half speed. If one SFCC fails, all flaps and slats operate at half speed.

Four Wingtip Brakes (WTBs) are activated in case of asymmetry, overspeed, symmetrical runaway, or uncommanded movement. The WTBs lock the flap or slat surfaces and prevent further movement. They cannot be released in flight.

• Note •

If the flap WTBs are on, the pilot can still operate the slats;
if the slat WTBs are on, he can still operate the flaps.

A flap disconnect detection system stops flap movement if excessive differential movement is detected between the inner and outer flaps on the same wing.

An "alpha lock" function inhibits retracting the slats from position 1 to 0 at a high angle of attack or low airspeed. The inhibition is removed automatically when the angle of attack is reduced or airspeed is increased.

Configurations. The flap lever has five positions: 0, 1, 2, 3, and FULL.

Position 1 has two configurations: 1 and 1+F. The actual configuration depends on flight phase (i.e., Takeoff, Approach, or Go-Around) and airspeed.

7-27.1.5 Flight Control Laws. Flight control laws are internal computer commands that control the flight controls to maintain priorities and limitations. There are three primary flight control laws: Normal, Alternate, and Direct.

Normal Law. Normal law is the normal operating configuration of the system. Failure of any single computer does not affect normal law. It covers three-axis control, flight envelope protection, and load alleviation. Normal law has three modes according to the phase of flight.

Ground Mode. The ground mode is active when the aircraft is on the ground. In this mode there is a direct proportional relationship between the sidestick deflection and the deflection of the flight controls. This mode is active until shortly after lift off. After touchdown, ground mode is reactivated and resets the stabilizer trim to 0.

Flight Mode. The flight mode becomes active shortly after takeoff and remains active until shortly before touchdown. In this mode the sidestick deflection and the load factor imposed on the aircraft are directly proportional, regardless of airspeed.

With the sidestick neutral and wings level, the system maintains a 1g load in pitch. There is no need for the pilot to change pitch trim to compensate for airspeed changes, configuration, or bank (up to 33°). At full aft or fwd sidestick deflection, the system will maintain the maximum load factor for the flap position.

When the pilot makes a roll input on the sidestick, the system interprets the command as a roll rate request and positions ailerons and spoilers 2 through 5 to maintain a constant bank. The roll rate is independent of airspeed; a given sidestick deflection will always result in the same roll rate response.

Turn coordination and yaw damping are computed by the ELACs and transmitted to the FACs. There is no rudder pedal feedback for the yaw damping and turn coordination functions.

Flare Mode. Transition to flare mode occurs at 50′ RA during landing. The system memorizes the pitch attitude at 50′ and then begins to progressively reduce pitch, forcing the pilot to flare the aircraft. In the event of a go around, transition to flight mode occurs again at 50′ RA.

Protections: Normal law protects the aircraft throughout the flight envelope as follows:

— Load factor limitation. Prevents the pilot from overstressing the aircraft, even if full sidestick deflections are applied.

— Attitude protection. Pitch is limited to 30° up, 15° down, and 67° of bank. These limits are indicated by green "=" signs on the PFD. Bank angles in excess of 33° require constant sidestick input. If the input is released, the aircraft returns to and maintains 33° of bank.

— High angle of attack protection. When the angle of attack exceeds α prot, elevator control switches to α protection mode in which angle of attack is proportional to sidestick deflection. However α max will not be exceeded even if the pilot applies full aft deflection.

— High speed protection. Prevents exceeding V_{MO} or M_{MO} by introducing a pitch up load factor demand. The pilot cannot override the pitch up command.

— Low energy warning. (Available in CONF 2, 3, or FULL, between 100′ and 2,000′ RA when TOGA not selected.) Produces aural "SPEED SPEED SPEED" when change in flight path alone is insufficient to regain a positive flight path. (Thrust must be increased.)

Alternate Law. If multiple system failures occur, the flight controls revert to alternate law. There are many different combinations of alternate flight control laws. The ECAM displays the message "ALTN LAW: PROT LOST." Depending on the specific failure, the autopilot may be available.

Ground Mode. The ground mode is identical to normal law.

Flight Mode. In pitch alternate law, the flight mode is a load factor demand law similar to the normal law flight mode; however, with reduced protections.

Pitch alternate law degrades to pitch direct law when the landing gear is extended. This provides the pilot with "feel" for the flare and landing, since there is no flare mode when pitch normal law is lost.

In alternate law, automatic pitch trim is available and yaw damping (with limited authority) is also available. Turn coordination is lost.

There is no roll alternate law. When pitch law degrades from normal law, roll always degrades to direct law. In this case roll rate depends on airspeed.

Protections: All protections except for load factor maneuvering protection are lost. Amber Xs replace the green "=" attitude limits on the PFD.

The load factor limitation is similar to that under normal law.

A low speed stability function replaces the normal angle-of-attack protection. The system introduces a progressive nose-down command which attempts to keep the speed from slowing further. This command can be overridden by sidestick input. ***The airplane can be stalled in alternate law.*** An audio stall warning consisting of "crickets" and a "STALL" aural message is also activated. The α floor function is inoperative.

Certain failures cause the system to revert to alternate law without speed stability. When this occurs, the control laws are identical to alternate law; however, the low and high speed stability functions are lost. Only the load factor protection is provided. In addition, yaw damping is lost if the fault is a triple ADR failure.

In alternate law, the PFD airspeed scale is modified. While V_{LS} remains displayed, Vα prot and Vα max are removed. They are replaced by a red and black barber pole. The top of the pole indicates the stall warning speed (V_{SW}).

A nose-up command is introduced any time the airplane exceeds V_{MO}/M_{MO} to keep the speed from increasing further. This command can be overridden by sidestick input.

Bank angle protection is lost.

Direct Law. Direct law is the lowest level of computer flight control and occurs with certain multiple failures. Pilot control inputs are transmitted unmodified to the control surfaces, providing a direct relationship between sidestick and control surface. Control sensitivity depends on airspeed and no autotrimming is available.

An amber message "USE MAN PITCH TRIM" appears on the PFD.

If the flight controls degrade to alternate law, direct law automatically becomes active when the landing gear is extended if no autopilots are engaged. If an autopilot is engaged, the airplane will remain in alternate law until the autopilot is disconnected.

There are no protections provided in direct law; however, overspeed and stall aural warnings are provided. The PFD airspeed scale remains the same as in alternate law.

Abnormal Attitude Laws. The abnormal attitude law is activated if the airplane enters an unusual attitude. This allows the pilot to recover from the unusual attitude. Pitch law becomes alternate (without autotrim and without protection, except load factor protection). Roll law becomes direct law with mechanical yaw control.

After recovery from the unusual attitude, the following laws are active for the remainder of the flight:

— pitch: alternate law without protections and with autotrim

— roll: direct law

— yaw: alternate law

There is no reversion to direct law when the landing gear is extended.

7-27.1.6 Mechanical Backup. In case of a complete loss of electrical flight control signals, the aircraft can be temporarily controlled by mechanical mode. Pitch control is achieved through the horizontal stabilizer by using the manual trim wheel(s). Lateral control is accomplished using the rudder pedals. Both controls require hydraulic power. A red "MAN PITCH TRIM ONLY" warning appears on the PFD.